

1 **CLAIMS:**

2 I claim:

3 1. A system for detecting errors in a printed copy, the system
4 comprising:

5 one or more computer memories having one or more digitized
6 source images;

7 one or more scanners that scan one or more printed copies to
8 create one or more corresponding scanned images;

9 an alignment process that creates an initial replacement
10 image from the scanned image, the replacement scanned image being
11 aligned with the digitized source image on a page by page, line
12 by line, and pel by pel basis; and

13 a comparison process that compares one or more source pels
14 of the digitized source image with one or more corresponding
15 scanned pels of the initial replacement image to determine
16 differences, the differences being defects in the printed copies.

17 2. A system for detecting errors in a printed copy, the system
18 comprising:

1 one or more computer memories having one or more digitized
2 source images;

3 a digital printer that converts the digitized source images
4 into one or more printed copies;

5 one or more scanners that scan the printed copies to create
6 one or more corresponding scanned images;

7 an alignment process creates a replacement image from the
8 scanned image, the replacement image being aligned with the
9 digitized source image on a page and page, line by line, and pel
10 by pel basis; and

11 a comparison process that compares one or more source pels
12 of the digitized source image with one or more corresponding
13 scanned pels of the replacement image to determine differences,
14 the differences being defects in the printed copies.

15 3. A system, as in claim 2, where the alignment process comprises
16 a course alignment and a subsequent fine alignment.

1 4. A system, as in claim 3, where the course alignment produces
2 an initial replacement image and the fine alignment produces a
3 final replacement image being the replacement image.

4 5. A system, as in claim 3, where the course alignment is a
5 repeated application of an affine transform of source image pels
6 and the fine alignment is a repeated application of a one
7 dimensional cross-correlation of one or more course aligned pels
8 to source pels.

9 6. A system, as in claim 2, where the alignment process comprises
10 the steps of:

11 embedding two or more vertical synchronization-strips into
12 the digitized source image;

13 printing the synchronization-strips on the printed copy;

14 scanning the printed copy so that two or more scanned
15 vertical synchronization-strips are embedded in the scan copy,
16 the vertical synchronization-strips being separated by a first
17 separation distance;

1 tracking the horizontal and vertical coordinates of one or
2 more sequential and specifically identifiable features in lines
3 of the synchronization-strip to create a line by line
4 correspondence between the source image and the corresponding
5 scanned image;

6 performing a scanned image pixel value interpolation based
7 on an affine transform, comprising the following steps:

8 sub dividing the source image and scanned image into
9 one or more source and scanned horizontal strips, respectively;

10 determining at least two corresponding points on two
11 corresponding lines in the source and scanned images, the two
12 corresponding lines separated by a second separation distance;

13 using at least four of the corresponding points, two at
14 a time from each of the lines to develop a transformation of the
15 coordinates of pels in the source image to points of interest in
16 the scanned image;

17 determining an interpolated pixel value of the scanned
18 image at the point of interest; and

1 for each pixel, placing the interpolated pixel value
2 into an initial replacement image at the pel coordinates
3 corresponding to the pel of the source image used to determine
4 the point of interest.

5

6 7. A system, as in claim 6, where the alignment process further
7 comprises the steps of:

8 dividing the source image into a plurality of initial source
9 horizontal strips;

10 dividing one of the source horizontal strips into a
11 plurality of source vertical stripes;

12 dividing the initial aligned image into a plurality of
13 initial aligned horizontal strips;

14 dividing one of the aligned horizontal strips into a
15 plurality of initial vertical stripes;

16 dividing the initial horizontal strip corresponding to the
17 respective source horizontal strips into a plurality of initial
18 vertical stripes, the source vertical stripes and the initial
19 vertical strips corresponding to one another and having the same
20 height and width;

1 determining three or more cross-correlation values between
2 the source and initial vertical stripes for an initial horizontal
3 alignment and two or more horizontal offsets between the source
4 and initial vertical stripes;

5

6 using the three or more cross-correlation values and their
7 corresponding offsets to further determine an interpolated offset
8 that produce the optimal correlation value;

9 producing an interpolated offset for each pair of source and
10 initial vertical stripes;

11 performing a piece-wise interpolation between the
12 interpolated offsets to develop a fine alignment that is
13 dependent on the horizontal pel position of the source image; and
14

15 re-performing the scanned image pixel value interpolation
16 wherein a horizontal coordinate of the pel of the source image is
17 increased by the piece-wise interpolated value of the fine
18 alignment.

19 8. A system, as in claim 2, where the comparison process uses
20 masks.

1 9. A system, as in claim 8, where the mask is a dilation mask.

2 10. A system, as in claim 8, where the mask is an erosion mask.

3 11. A system, as in claim 2, where the comparison process
4 comprises the steps of:
5
6 dilating the source image;
7
8 eroding the replacement image;
9
10 bit-wise **or**'ing the corresponding one-bit pel values of the
11 dilated source image and the eroded replacement image to produce
12 a first intermediate result;
13
14 bit-wise **exclusive-or**'ing the first intermediate result with
15 the one-bit pel values of the dilated source image to indicate
16 the pel locations of excess ink in the scanned image.

17 12. A system, as in claim 11, where the comparison process
18 further comprises the step of:
19
20 declaring a defect only if two or more adjacent pel
21 locations have an excess of ink.

1 13. A system, as in claim 12, where the defect is declared in at
2 least one of the following situations: two or more horizontally
3 adjacent pel locations have an excess of ink, two or more
4 vertical adjacent pel locations have an excess of ink, and two or
5 more horizontally adjacent and two or more vertical adjacent pel
6 locations have an excess of ink.

7 14. A system, as in claim 2, where the comparison process
8 comprises the steps of:

9 dilating the replacement image;

10 eroding the source image;

11 bit-wise **and**'ing the corresponding one-bit pel values of the
12 dilated replacement image and the eroded source image to produce
13 a second intermediate result;

14 bit-wise **exclusive-or**'ing the second intermediate result
15 with the one-bit pel values of the eroded source image to
16 indicate the pel locations of missing ink in the scanned image.

17 15. A system, as in claim 14, where the comparison process
18 further comprises the step of:

1 declaring a defect only if two or more adjacent pel
2 locations are missing ink.

3 16. A system, as in claim 14, where the defect is declared in at
4 least one of the following situations: two or more horizontally
5 adjacent pel locations are missing ink, two or more vertical
6 adjacent pel locations are missing ink, and two or more
7 horizontally adjacent and two or more vertical adjacent pel
8 locations are missing ink.

9 17. A system, as in claim 2, where the comparison process
10 comprises the steps of:

11

12 thresholding and dilating the source image;

13 thresholding and eroding the replacement image;

14

15 bit-wise **or**'ing the corresponding pel values of the dilated
16 source image and the eroded replacement image to produce a first
17 intermediate result;

18 bit-wise **exclusive-or**'ing the first intermediate result with
19 the dilated source image to indicate the pel locations of excess
20 ink and stray marks in the scanned image.

1 18. A system, as in claim 17, where the threshold is any one of
2 the following percentage of the initial pixel values: 5% - 95%,
3 25%, and 50%.

4 19. A system, as in claim 2, where the comparison process
5 comprises the steps of:

6 thresholding and dilating the replacement image;

7 thresholding and eroding the source image;

8 bit-wise **and**'ing the corresponding pel values of the dilated
9 replacement image and the eroded source image to produce a second
10 intermediate result;

11 bit-wise **exclusive-or**'ing the second intermediate result
12 with the eroded source image to indicate the pel locations of
13 missing ink in the scanned image.

14 20. A system, as in claim 19, where the threshold is any one of
15 the following percentage of the initial pixel values: 5% - 95%,
16 25%, and 50%.

17 21. A system, as in claim 2, where the scanner has a line array
18 sensor.

1 22. A system, as in claim 21, where the line array sensor is
2 compensated so that all pixels that sense only black ink printed
3 on paper produce the same black numeric value and that all pixels
4 that sense blank paper produce the same white numeric value.

5 23. A method for aligning content on a printed page, the method
6 comprising the steps of:

7 embedding two or more synchronization-strips into a
8 digitized source image to form a marked source image; and

9 printing the marked source image to form a printed copy, the
10 embedded synchronization-strips containing line identification of
11 one or more lines of the printed copy.

12 24. A method, as in claim 23, further comprising the steps of:

13 scanning the printed copy so that two or more scanned
14 vertical synchronization-strips are embedded in a scanned image,
15 the vertical synchronization-strips being separated by a first
16 separation distance; and

1 tracking the horizontal and vertical coordinates of one or
2 more sequential and specifically identifiable features in the
3 synchronization-strip to create a line by line correspondence
4 between the marked source image and the corresponding scanned
5 image.

6 25. A method, as in claim 24, further comprising the steps of:

7 performing a scanned image pixel value interpolation based
8 on an affine transform, the affine transform comprising the
9 following steps:

10 sub dividing the source image and scanned image into
11 one or more source and scanned horizontal strips, respectively;

12 determining by synchronization-strip tracking at least
13 two corresponding points on two corresponding lines in the source
14 and scanned images, the two corresponding lines separated by a
15 second separation distance;

16 using at least four of the corresponding points, two at
17 a time from each of the lines to develop a transformation of the
18 coordinates of pels in the source image to points of interest in
19 the scanned image;

1 determining an interpolated pixel value of the scanned
2 image at the point of interest; and

3 for each pixel, placing the interpolated pixel value
4 into an initial replacement image at the pel coordinates
5 corresponding to the pel of the source image used to determine
6 the point of interest.

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8 26. A system, as in claim 23, where the alignment process further
9 comprises the steps of:

10 dividing the source image into a plurality of initial source
11 horizontal strips;

12 dividing one of the source horizontal strips into a
13 plurality of source vertical stripes;

14 dividing the initial aligned image into a plurality of
15 initial aligned horizontal strips;

16 dividing one of the aligned horizontal strips into a
17 plurality of initial vertical stripes;

1 dividing the initial horizontal strip corresponding to the
2 respective source horizontal strips into a plurality of initial
3 vertical stripes, the source vertical stripes and the initial
4 vertical strips corresponding to one another and having the same
5 height and width;

6 determining three or more cross-correlation values between
7 the source and initial vertical stripes for an initial horizontal
8 alignment and two or more horizontal offsets between the source
9 and initial vertical stripes;

10

11 using the three or more cross-correlation values and their
12 corresponding offsets to further determine an interpolated offset
13 that produce the optimal correlation value;

14 producing an interpolated offset for each pair of source and
15 initial vertical stripes;

16 performing a piece-wise interpolation between the
17 interpolated offsets to develop a fine alignment that is
18 dependent on the horizontal pel position of the source image; and
19

1 re-performing the scanned image pixel value interpolation
2 wherein a horizontal coordinate of the pel of the source image is
3 increased by the piece-wise interpolated value of the fine
4 alignment.

5 27. A system for aligning content on a printed page, the system
6 comprising:

7 means for embedding two or more synchronization-strips into
8 a digitized source image to produce a marked source image; and

9 means for printing the marked source image containing the
10 synchronization-strips on a printed copy, the
11 synchronization-strips containing line identification of one or
12 more lines of the printed copy.

13 28. A system for aligning content in a printed copy, the system
14 comprising:

15 one or more scanners that scan one or more printed copies to
16 create one or more corresponding digitized scanned images;

17 an alignment process that embeds two or more
18 synchronization-strips into a digitized source image to produce a
19 marked source image; and

1 printer that prints the marked source image with the
2 embedded synchronization-strips to form the printed copy, the
3 synchronization-strips containing line identification of one or
4 more lines of the printed copy.

5 29. A system, as in claim 28, where the printer prints one or
6 more of the synchronization-strips in any one or more of the
7 following locations: in a vertical gutter between pages printed
8 on a web segment and in a vertical sacrificial part of the web
9 segment.

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